APPENDIX P   **DEFAULT VALUES FOR RISK ASSESSMENT EQUATIONS**

Table 1: **Standard Default Factors**

Symbol	Definition (units)	Default	Reference
CSFo	Cancer slope factor oral $(mg/kg\text{-}d)^{-1}$		IRIS, HEAST, or NCEA
CSFi	Cancer slope factor inhalation $(mg/kg\text{-}d)^{-1}$		IRIS, HEAST, or NCEA
RfDo	Reference dose oral (mg/kg-d)		IRIS, HEAST, or NCEA
RfDi	Reference dose inhalation (mg/kg-d)		IRIS, HEAST, or NCEA
TR_A	Target cancer risk (WoE=A)[a]	10^{-6}	
$TR_{B,C}$	Target cancer risk (WoE=B1, B2, C)[b]	10^{-5}	
THQ	Target hazard quotient	1	
BWa	Body weight, adult (kg)	70	RAGS (Part A), USEPA 1989 (EPA/540/1-89/002)
BWc	Body weight, child (kg)	15	Exposure Factors USEPA 1991 (Oswer No. 9285.6-03)
ATc	Averaging time-carcinogens (days)	25550	RAGS (Part A), USEPA 1989 (EPA/540/1-89/002)
ATn	Averaging time-noncarcinogens (days)	ED*365	RAGS (Part A), USEPA 1989 (EPA/540/1-89/002)
SAa	25% Surface area, adult (cm^2/day)	5000	Dermal Assessment, USEPA 1992 (EPA/600/8-91/011B)
SAc	25% Surface area, child (cm^2/day)	2000	Dermal Assessment, USEPA 1992 (EPA/600/8-9/011B)
AF	Adherence factor (mg/cm^2)	0.2	Dermal Assessment, USEPA 1992 (EPA/600/8-9/011B)
ABS	Skin absorption (unitless): ▸ organics ▸ inorganics	0.1 0.01	PEA, Cal-EPA (DTSC, 1994) PEA, Cal-EPA (DTSC, 1994)
IRAa	Inhalation rate- adult (m^3/day)	20	Exposure Factors, USEPA 1991 (OSWER No. 9285.6-03)
IRAc	Inhalation rate- child (m^3/day)	10	RAGS (Part A), USEPA 1989 (EPA/540/1-89/002)

Continue Table 1:   Standard Default Factors

Symbol	Definition (units)		Default	Reference
IRSa	Soil ingestion - adult (mg/day)		100	Exposure Factors, USEPA 1991 (OSWER No. 9285.6-03)
IRSc	Soil ingestion - child (mg/day)		200	Exposure Factors, USEPA 1991 (OSWER No. 9285.6-03)
IRSo	Soil ingestion - occupational (mg/day)		50	Exposure Factors, USEPA 1991 (OSWER No. 9285.6-03)
EFr	Exposure frequency - residential (d/y)		350	Exposure Factors, USEPA 1991 (OSWER No. 9285.6-03)
EFo	Exposure frequency - occupational (d/y)		250	Exposure Factors, USEPA 1991 (OSWER No. 9285.6-03)
EDr	Exposure duration - residential (years)		30[c]	Exposure Factors, USEPA 1991 (OSWER No. 9285.6-03)
	Exposure duration - child (years)		6	
EDo	Exposure duration - occupational years		25	Exposure Factors, USEPA 1991 (OSWER No. 9285.6-03)
Age-adjusted factors for carcinogens:				
IFSadj	Ingestion factor, soils ([mg•yr]/[kg•d])		114	RAGS (Part B), USEPA 1991 (OSWER No. 9285.7-01B)
SFSadj	Skin contact factor, soils ([mg•yr]/[kg•d])		503	By analogy to RAGS (Part B)
InhFadj	Inhalation factor ([m^3•yr]/[kg•d])		11	By analogy to RAGS (Part B)
PEF	Particulate emission factor (m^3/kg)		1.396×10^9	Soil Screening Guidance (USEPA 1996 a,b)
VFs	Volatilization factor for soil(m^3/kg)		Chem. Specific	Soil Screening Guidance (USEPA 1996 a,b)
Csat	Soil saturation concentration (mg/kg)		Chem. Specific	Soil Screening Guidance (USEPA 1996 a,b)

a USEPA Carcinogenic Weight of Evidence (WoE) Classification A for Known Human Carcinogens

b USEPA Carcinogenic WoE Classification B1 or B2 for Probable Human Carcinogens, and C for Possible Human Carcinogens

c Exposure duration for lifetime residents (30 years) is integrated for childhood (6 years) and adulthood (24 years).

Equations

(1) Integrated Ingestion Adjustment Factor for Residential Exposure to Carcinogens

$$IFS_{adj} = \frac{ED_c \times IRS_c}{BW_c} + \frac{(ED_r - ED_c) \times IRS_a}{BW_a}$$

(2) Integrated Inhalation Adjustment Factor for Residential Exposure to Carcinogens

$$InhF_{adj} \quad \frac{ED_c \times IRA_c}{BW_c} + \frac{(ED_r - ED_c) \times IRA_a}{BW_a}$$

(3) Integrated Dermal Adjustment Factor for Residential Exposure to Carcinogens

$$SFS_{adj} = \frac{ED_c \times AF \times SA_c}{BW_c} + \frac{(ED_r - ED_c) \times AF \times SA_a}{BW_a}$$

d Volatilization Factor (VF) from equation 8 is used for volatile organic compounds. Particulate Emission Factor (PEF) from equation 10 is used for semi-volatile and non-volatile compounds.

Equations

(4) Combined Exposures to Carcinogenic Contaminants in Residential Soil

$$C_{(mg/kg)} = \frac{TR \times AT_c}{EF_r \left[\left(\dfrac{IFS_{adj} \times CSF_o}{10^6 mg/kg} \right) + \left(\dfrac{SFS_{adj} \times ABS \times CSF_o}{10^6 mg/kg} \right) + \left(\dfrac{InhF_{adj} \times CSF_i}{VF^d_s} \right) \right]}$$

(5) Combined Exposures to Noncarcinogenic Contaminants in Residential Soil

$$C_{(mg/kg)} = \frac{THQ \times BW_c \times AT_n}{EF_r \times ED_c \left[\left(\dfrac{1 \times IRS_c}{RfD_o \; 10\,mg/kg} \right) + \left(\dfrac{1 \times SA_c \times AF \times ABS}{RfD_o \quad 10^6 mg/kg} \right) + \left(\dfrac{1 \times IRA_c}{RfD_i \; VF^d_s} \right) \right]}$$

(6) Combined Exposures to Carcinogenic Contaminants in Non-residential Soil

$$C_{(mg/kg)} = \frac{TR \times BW_a \times AT_c}{EF_o \times ED_o \left[\left(\dfrac{IRS_o \times CSF_o}{10^6 mg/kg} \right) + \left(\dfrac{SA_a \times AF \times ABS \times CSF_o}{10^6 mg/kg} \right) + \left(\dfrac{IRA_a \times CSF_i}{VF^d_s} \right) \right]}$$

(7) Combined Exposures to Noncarcinogenic Contaminants in Non-residential Soil

$$C_{(mg/kg)} = \frac{THQ \times BW_a \times AT_n}{EF_o \times ED_o \left[\left(\dfrac{1 \times IRS_o}{RfD_o \; 10^6 mg/kg} \right) + \left(\dfrac{1 \times SA_a \times AF \times ABS}{RfD_o \quad 10^6 \, mg/kg} \right) + \left(\dfrac{1 \times IRA_A}{RfD_i \; VF^d_s} \right) \right]}$$

Equations

(8) Derivation of the Volatilization Factor

$$VF_s(m^3/kg) = \frac{(Q/C) \times (3.14 \times D_A \times T)^{1/2} \times 10^{-4}(m^2/cm^2)}{2 \times \rho_b \times D_A}$$

Where:

$$D_A = \frac{[(\Theta_a^{10/3} D_i H' + \Theta_w^{10/3} D_w) / n^2]}{\rho_b K_d + \Theta_w + \Theta_a H'}$$

Parameter	Definition (units)	Default
VFs	Volatilization factor (m³/kg)	
D_A	Apparent diffusivity (cm²/s)	
Q/C	Inverse of the mean concentration at the center of a 0.5 acre square source (g/m²-s per kg/m³)	68.81
T	Exposure interval (s)	9.5×10^8
ρ_b	Dry soil bulk density (g/cm³)	1.5
Θ	Air filled soil porosity (L_{air}/L_{soil})	0.28 or n-Θ_w
n	Total soil porosity (L_{pore}/L_{soil})	0.43 or 1- (ρ_b/ρ_s)
Θ_w	Water-filled soil porosity (L_{water}/L_{soil})	0.15
ρ_s	Soil particle density (g/cm³)	2.65
Di	Diffusivity in air (cm²/s)	Chemical-specific
H	Henry's Law constant (atm-m³/mol)	Chemical-specific
H'	Dimensionless Henry's Law constant	Calculated from H by multiplying by 41 (USEPA 1991a)
D_w	Diffusivity in water (cm²/s)	Chemical-specific
K_d	Soil-water partition coefficient (cm³/g)=$K_{oc}f_{oc}$	Chemical-specific
K_{oc}	Soil organic carbon-water partition coefficient (cm³/g)	Chemical-specific
f_{oc}	Fraction organic carbon in soil (g/g)	0.006 (0.6%)

Equations

(9) Derivation of the Soil Saturation Limit

$$Csat = (S / \rho_b) (K_d \rho_b + \Theta_w + H' \Theta_a)$$

Parameter	Definition (units)	Default
Csat	Soil saturation concentration (mg/kg)	
S	Solubility in water (mg/L-water)	Chemical-specific
ρ_b	Dry soil bulk density (kg/L)	1.5
K_d	Soil-water partition coefficient (L/kg)	$K_{oc} \times f_{oc}$
K_{oc}	Soil organic carbon/water partition coefficient (L/kg)	Chemical-specific
f_{oc}	Fraction organic carbon content of soil (g/g)	0.006
Θ_w	Water-filled soil porosity (L_{water}/L_{soil})	0.15
Θ_2	Air filled soil porosity (L_{air}/L_{soil})	0.28 or $n-\Theta_w$
w	Average soil moisture content (kg_{water}/kg_{soil} or L_{water}/kg_{soil})	0.1
H	Henry's Law constant (atm-m³/mol)	Chemical-specific
H′	Dimensionless Henry's Law constant	H x 41, where 41 is a units conversion factor
n	Total soil porosity (L_{pore} / L_{soil})	0.43 or $1 - (\rho_b/\rho_s)$
ρ_s	Soil particle density (kg / L)	2.65

Equations

(10) Derivation of the Contaminant Concentration at 1% Free-Phase

$$C_{1\%} = Csat + \frac{n\,n_r\,\rho_f}{\rho_b} \times 10^6 \ (mg \cdot cm^3 / g \cdot L)$$

Parameter	Definition (units)	Default
$C_{1\%}$	Contaminant concentration at 1% Free-Phase (mg/kg)	
Csat	Soil saturation concentration (mg/kg)	Chemical-specific
n	Total soil porosity (L_{pore}/L_{soil})	0.43
n_r	Residual in saturation in free-product phase (L_{FP}/L_{pore})	0.01
ρ_f	Fluid density of contaminant (g/cm³)	Chemical-specific
ρ_b	Dry soil bulk density (kg/L)	1.5

Equations

(11) Derivation of the Particulate Emission Factor

$$\text{PEF (m}^3\text{/kg)} = Q/C \times \frac{3600 \text{ s/h}}{0.036 \times (1-V) \times (U_m/U_t)^3 \times F_{(x)}}$$

Parameter	Definition (units)	Default
PEF	Particulate emission factor (m³/kg)	1.316×10^9
Q/C	Inverse of the mean concentration at the center of a 0.5-acre-square source (g/m²-s per kg/m³)	90.80
V	Fraction of vegetative cover (unitless)	0.5
U_m	Mean annual windspeed (m/s)	4.69
U_t	Equivalent threshold value of windspeed at 7 m (m/s)	11.32
F (x)	Function dependent on U_m/U_t derived using Cowherd (1985) (unitless)	0.194

GLOSSARY

HEAST . . . . USEPA Health Effects Assessment Summary Tables

IRIS . . . . USEPA Integrated Risk Information System

NCEA . . . . USEPA National Center for Environmental Assessment

PEA . . . . Preliminary Endangerment Assessment

RAGS . . . . Risk Assessment Guidance for Superfund

USEPA . . . . United States Environmental Protection Agency

CalEPA . . . . California Environmental Protection Agency

OSWER . . . . Office of Solid Waste and Emergency Response

DTSC . . . . Department of Toxic Substances Control